CONTROLLING RADIOACTIVE FALLOUT CONTAMINATION

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FALLOUT FROM NUCLEAR TESTING

Many people are concerned about possible contamination of the Nation's food and milk supply with radioactive fallout from nuclear tests.

Our milk and food are not in danger today from such contamination. Radiation levels are still below the point of any serious concern. Conservative estimates place the daily consumption of strontium 90 in our entire diet at the lower levels of Range II of the Federal Radiation Council's recommended standards and guides -- considerably below the levels at which special countermeasures would be considered.

Milk represents one of our Nation's most important foods. It forms a major part of the diet of infants and growing children. Its consumption by teen-agers and pregnant mothers is highly desirable. Its nutritional elements, as the Food and Nutrition Board of the National Academy of Sciences pointed out, would be difficult to replace without considerable added expense.

Even with the abundant food supplies available in this country, the White House Conference on Youth in 1960 reported that over 30 percent of our teenage girls lack sufficient calcium in their diet. The diets of twenty percent of the boys in the same age group were likewise deficient. These deficiencies could cause more serious consequences than present levels of radioactive contamination.

Medical and public health authorities have been concerned for some time that many people might give up drinking milk or eating essential foods for fear they may be contaminated with radioactivity. That kind of reaction could do far more harm to health than the infinitesimal amounts of radioactivity found in some foods. This concern has been expressed by such authorities as Dr. Luther L. Terry, Surgeon General of the Public Health Service; Dr. Donald R. Chadwick, Chief, Division of Radiological Health, Public Health Service; Dr. Herman E. Hilleboe, Commissioner of Health, State of New York; and Dr. Cyril L. Comar, Biologist, Cornell University.

The National Advisory Committee on Radiation, composed of authorities in the fields of medicine, public health, and health physics, has stated that there is a tendency of certain groups of the population to make their own interpretations of published levels of radiocontamination and to urge the application of those countermeasures which seem appropriate. The

Committee urges the avoidance of independent countermeasure action. Not infrequently, such action involves the use of countermeasures which are associated with risks approaching or exceeding those of the contaminant. Often, such action is ineffective in reaching the objectives sought.

The Public Health Service is keeping a continual watch on the levels of radioactivity showing up in vegetables and dairy products. It is their conclusion that at the present levels we will all be much better off drinking milk and eating vegetables as usual rather than reducing our consumption of these essential foods.

Much of the public discussion of fallout hazards has centered about the radioisotope strontium 90. A review of available research studies indicates that detrimental effects of strontium 90 have never been observed in humans. There is no evidence at this time of strontium 90 damage to humans, and specifically there are no reported cases of bone cancer or leukemia in man caused by strontium 90. Experiments with small laboratory animals have shown, however, that strontium 90 can produce injury when consumed in sufficiently large amounts. It is therefore prudent to assume that people might also be injured if exposed to significantly large quantities.

In the current concern for the consumption of radioactive materials in our food supply, emphasis must be placed on the serious limitation that exists in our knowledge of measuring the effects of radiation on the biological system. In fact, this limitation also applies to measurement of all causes and effects on living organisms.

In most cases, we can measure and know the effects of relatively large doses of radiation on a mammal. Experimentally, we can reduce these doses and observe that the reaction decreases. But we usually find that we can reduce the dose to a level where our present experimental techniques are not capable of revealing the results.

Doses of radiation that people may be receiving from fallout are far below the level that produces effects we can measure or observe at this time. Therefore, exact answers cannot be given to questions on the effects of present fallout levels. How can we conclude that an extremely low level of radiation may or may not be harmful to, say, one person out of a hundred thousand or one person in a million? We just cannot measure such minute effects.

Can we, or should we, accept the minute possibility of damage -- the unmeasured possibility of harmful effects associated with fallout at current levels, or even with considerably higher levels? We certainly have precedents galore for learning to live with hazards of this magnitude in our environment.

What about the countless highway and traffic accidents and the resultant mortality?

Do we know the effects of smog, or the excessive use of tobacco or alcohol, or the extended use of reducing diets, mixtures, and fashionable food fads?

None of these seems to produce the public concern or excite the interest of newspapers and popular magazines the way radioactive fallout does. The current reaction toward fallout is not consistent with reaction to other hazards in our environment. There may be special explanations for the attitudes that some people seem to have developed toward radioactive fallout, but some of them are extremely difficult to define.

Much of the concern with the radioactive fallout is due to a mystery psychology -- a fear of the unknown. People know only that this something is quietly and invisibly dropping from the sky.

It is well to remember that radiation has always been with us. Life on earth has developed to its present state (good or bad) amid continuous natural radiation from rocks, soil, and outer space. Dr. Edward Teller, atomic scientist of the University of California, and known as father of the H-bomb, points out that the average American gets an annual dose of cosmic rays averaging .034 roentgen per year at sea level. People at higher altitudes, specifically Denver, get a larger dose of .05 roentgen per year. Compare this continual exposure with that from world-wide radiation from fallout. Dr. Teller points out that the bones of humans average .003 roentgen per year from strontium 90. He estimates that at these levels, a person is not apt to receive over a 1-roentgen dose from this source during his lifetime. This indicates that we get about 10 to 20 times the amount of radiation from cosmic rays as we do from strontium 90. Dr. Teller calculates that people living in brick houses may receive more radiation from the radioactive material contained in the bricks than from current levels of strontium 90.

FALLOUT FROM A NUCLEAR ATTACK

A nuclear attack on this country would produce fallout and radiation problems much different and many times more serious than those resulting from nuclear testing.

A conscientious historian has found that 278 wars have been waged by man from the time of Columbus' discovery of America until the beginning of World War II. Since then small and large conflicts have been numerous in all parts of the world. War appears as the most common means of accomplishing man's lust for power or imposing his own desires or philosophy on a people.

Each age has faced the terror of the ultimate weapon -- from the wooden club and the crossbow to cavalry, gunpowder, tanks, and planes. Now we face the threat of nuclear weapons. War in the 20th century with rockets and nuclear devices no longer confines its threat to the individual, the family, the village, or even the nation. Today, war is a threat to the world.

In the meantime, however, we must find ways of defending ourselves against an all-out nuclear attack and means of minimizing its effects. Such a nuclear attack against this country would create many difficulties. Our agriculture and food industry would be faced with some special problems -- including food production, food processing, and food distribution. Certainly, the maintenance and safety of our food supply is one of the most vital considerations in any national emergency.

Among our major concerns in food production following a nuclear attack would be the provision of a safe, adequate food supply. We would want to do everything we could to save our important food resources from the effects of radioactive fallout.

What is radioactive fallout? It's the dustlike material created when a nuclear bomb explodes close to the ground. Thousands of tons of earth and other materials rise in the mushroom cloud and combine with radioactive debris from the bomb. Fallout is a mixture of melted and unmelted grains of soil. Radioactive atoms produced during the explosion condense into and onto these particles to form the radioactive fallout.

The danger is the nuclear radiation emitted from this fallout. The predominating nuclear radiation hazard from fallout is the gamma radiation which travels through air from particles lying on surrounding exposed surfaces and ground areas. This radiation can pass into and through matter. As it does, it can change, damage, or destroy living cells through a phenomenon known as ionization.

Fortunately, although ionization <u>does</u> change living cells and other materials, it does <u>not</u> make the affected cells or materials radioactive. Once the source of the radiation -- the radioactive fallout -- has been removed, the irradiated materials are safe to handle or to eat.

The primary concern should always be to keep the (gamma) radiation exposures to humans as low as possible -- for example, to protect the dairy farmer and his family from this hazard. This should be followed by efforts to protect the livestock from this hazard.

On the dairy farm following a nuclear attack, the dairyman would initially be concerned with the effects on milk production. Since most livestock would be outside the range of the initial effects of the weapons, the main question would be how much radiation the animals had been exposed to.

Many of the dairy animals would likely be in the open. They would receive radiation damage from external sources. They would also ingest radioactive materials of fallout that would contaminate pastures and other growing crops.

Other animals would be in a barn or under some cover and would be fed from reserve food supplies that were uncontaminated. In this case, our only concern would be how well the cover had protected the animals from external gamma radiation.

And finally, there would be animals under similar cover but fed from contaminated feed supplies. Here again, the possibility of damage from both external and internal radiation would have to be considered.

You can see that we would face two sources of radiation hazards -- an external source accompanying the arrival of fresh fallout in an area, and an internal source from contaminated feed and water that are consumed.

The major external hazard is due to gamma rays. These are similar to X-rays -- penetrating and capable of traveling some distance from the fallout where they originate. Our major problem with fresh fallout would be protection, through adequate shelter, against these rays. They are produced in large part by the shorter-lived isotopes; the intensity of gamma radiation decreases in a relatively short time through the process of radioactive decay.

The gamma-producing isotopes can also cause an internal hazard by contaminating feed and water.

But the internal hazard arises also from beta particles, or "rays," emitted from the longer-lived isotopes. These rays travel only a short distance in air and only a few millimeters in tissue. Protection against their external effects is relatively simple. However, once beta-particle emitters are ingested, they can, while inside the body, continue to emit radiation which damages the surrounding cells.

Thus, in our efforts to protect livestock, we must be prepared to deal with two needs:

First, we must protect against the immediate hazard from gamma radiation long enough to allow the fallout to decay to less hazardous levels.

Second, we must protect against the persistent hazard from consumption of contaminated feed and water.

Let's look more closely at these two threats from radiation and the means we have for dealing with them.

First, the external hazard.

Tolerance to radiation varies among species of animals, as well as among animals of the same species. All domestic animals, however, have a similar response to total body irradiation. Few, if any, will die following exposure up to 250 roentgens and few, if any, will survive after brief doses of as high as 1,000 roentgens. The smaller the dose and the slower the rate, the better radiation can be tolerated. Body size seems to have little to do with survival, although very young or very old animals may be more radiosensitive.

Table 1.--Percentage of mortality of unsheltered animals after 24-hours' exposure to various radiation doses

Species	Mortality 100%	80%	50%	20%	0
	Exposure dose (roentgens) 1/				
Cattle	650	600	550	450	300
Sheep	700	600	525	450	350
Swine	800	700	600	450	350
Poultry	1200	1100	900	600	400

1/ Exposure dose in area where livestock and building are located.

In the case of livestock, acute total body radiation exposures of 500 to 600 roentgens provide a mid-lethal dose -- that is, the amount that would be expected to kill half of a large group of exposed animals within 30 days.

Poultry have more resistance. Their mid-lethal dose is about 900 roentgens. Incidentally, in addition to being more resistant, poultry are usually raised under shelter and fed stored feed. So they would offer one of the more dependable sources of fresh foods of animal origin after a nuclear attack.

There would be some danger of external radiation damage to animals from the principal internal hazard -- the beta particles. If they come into actual contact with the skin and remain for an appreciable time, a form of radiation damage referred to as "beta burns" will result. The outer layers of the skin could receive a large radiation dose from the beta particles and in some circumstances this might cause serious burns.

Limited experimental evidence and field testing indicate that animals that fail to develop "beta burns" will ordinarily escape serious external radiation injury. Animals that sustain exposure intense enough to produce beta burns but live longer than 3 weeks or a month fall into the same category as those without burns.

Initially, the greatest fallout hazard to animals would be the gamma rays.

The most valuable protection against gamma rays would come from keeping livestock under adequate cover at least during the first critical 24 to 48 hours -- and longer if possible. With sufficient mass of shielding materials between the animals and the fallout, only a little of the radiation from gamma rays would penetrate into the sheltered area.

Distance would also afford some protection. The farther animals were from the source of radiation -- the radioactive fallout -- the less the exposure would be.

The value of shielding in preventing death and sickness among animals would be greatest in areas exposed to acute radiation doses about equal to the average mid-lethal dose. (See table 2.) Even at low radiation intensities, however, there would be some beneficial effect from shelter. It would help to prevent fallout from contaminating the animal's coat and would minimize the hazard of contaminating herdsmen and livestock handlers.

An effective barn for fallout protection is the multi-story building with a loft full of hay or straw, and soil or other shielding material banked against the sides of the building. Ten feet of baled hay will give as much shielding against gamma rays as 1 foot of earth. About one-fourth of the new dairy barns being built today in the large northern dairy states are of the high-roof type (Gambrel or Gothic) with overhead hay mows. The most effective protection would be found in underground basements such as we find in bank barns. Milking cows should be given the most protected location in the center of the barn. This would be the safest place for them as well as attending personnel who do the milking.

Protection against light fallout would be provided by open hay storage buildings and pole structures for livestock shelter and feeding. Even a shed without sides would give some protection.

If there are only enough buildings to house some of the animals, the others should be put in a yard, near farm buildings. Large protected self-feeders and automatic waterers could be an important source of uncontaminated feed and water under these conditions.

Construction plans are available through State Extension agricultural engineers for an elaborate dairy barn and family fallout shelter. Although construction of this type is costly and does not lend itself to efficient operation, such a facility might be considered for protection of highly valued breeding stock. It is designed in accordance with milk production ordinances. Here are some of the features of this plan:

1. A year-round production unit requires minimum changes for emergency use.

2. A built-in family shelter allows the operator to care for animals during a fallout emergency.

3. All stored feed is manually accessible inside the barn.

4. Stored hay and straw are used for shielding.

5. Other livestock could be temporarily housed, fed, and watered inside.

Table 2.--Effect of shelter on the mortality rate of livestock 1/

Kind of livestock and radiation exposure--unsheltered dose (no. of roentgens-1 day)	Mortality rate by nature of shelter			
	No shelter	Tight wooden barn (protection factor of 2)	2-story barn with loft full of hay (protection factor of 5)	Basement-type barn with loft full of hay (protection factor of 10 or more)
	Percent	Percent	Percent	Percent
CATTLE				
500	30	0	0	0
1000	100	30	0	0
3000	100	100	80	0
HOGS				
500	30	0	0	0
1000	100	30	0	0
3000	100	100	50	0
SHEEP				
500	38	0	0	0
1000	100	38	0	0
3000	100	100	80	0
POULTRY				
500	10	0	0	0
1000	64	10	0	0
3000	100	100	20	0

1/ The reduction of radiation by shelter is described as the "protection factor." For example, if the protection factor of any given structure is 2, then the intensity of outside radiation is reduced by one-half. In fallout areas, one-half or more of the radiation would be released after the end of the first day.

6. An auxiliary generator assures electric power.

7. The water supply pump is inside the barn.

Such a facility would not be practical for most farmers. But, as we have seen in areas of moderate fallout, good use of the usual facilities found on farms would do much to provide protection against the external hazard from radiation.

Let's turn now to the problem of protecting livestock from the internal hazard.

Many different radioisotopes are created by a nuclear explosion. Most of them are of minor importance because the amounts are small, their half-life is extremely short, or they don't find their way into the food chain where they could affect man and animals.

But four of these isotopes are capable of entering the food chain and contaminating crops as well as foods of animal origin. The four are cesium 137, iodine 131, strontium 89, and strontium 90. Each presents a different problem.

Cesium 137 is chemically similar to the essential element potassium. When consumed and absorbed, this radioisotope is found primarily in the soft tissues. However, like potassium, it is not retained long in the body and is rapidly secreted in the milk or excreted in the wastes.

Iodine 131 is the radionuclide of primary concern when one considers the short-lived nuclides of public health significance. Because of its similarity to ordinary iodine, this isotope can accumulate in the thyroid gland and is also secreted in the milk from dairy cows. Iodine 131 has a relatively short half-life of 8 days and would be the major internal hazard during the first 60 days following a nuclear attack.

There are considerable day-to-day variations in the average level of iodine 131 in milk. Values have varied on occasions by a factor of about 2. This is not unexpected, however, as iodine 131 is rapidly transferred to milk (within 24 hours). Shortly after detonation the iodine 131 content of both air and rainwater may vary rapidly. Uncontaminated rain could cause rapid reduction in the iodine 131 content of growing forage crops.

There are no practical ways at the moment of preventing a cow from secreting radioactive iodine in her milk if she is allowed to consume feed contaminated with this radionuclide. In fact, up to now, this has not been a fruitful avenue for research. The answer is to prevent the cow from consuming radioactive materials -- or at least minimize the amount ingested. Limited studies have been made on comparing radioiodine in the milk of barn-fed with pasture-fed dairy herds. One such study indicated that the levels of radioactivity from worldwide fallout in milk

from barn-fed animals were essentially nondetectable while the secretions and excretions of pasture-fed cows contained several radioactive isotopes, including iodine 131.

Studies have further shown only negligible quantities of iodine 131 in milk after herds have been on iodine-free feed for as short a period as 5 to 7 days.

COUNTERMEASURES

Countermeasures against fallout contaminants include those actions and procedures that would result in reducing or eliminating the exposure of the population to the hazards of radioactive materials. These procedures should be directed to the source of the contamination, to the mechanism that transmits it, or to the substance in which it gains access.

Countermeasures would be taken only after responsible authorities had carefully evaluated the situation and declared a state of emergency. The decision would not be an easy one. Medical assessment of the probable damage from radiation would have to be balanced against the cost of the decontamination measures, the resulting reduction in available food supplies, and the economic and social dislocations resulting from the action.

Countermeasures could be drastic, or they could involve changes in generally accepted farming practices. Some measures could be simply an improvement over local conditions and procedures. Some countermeasures could result in reducing the contaminant by only a small factor, but a combination of several of these measures could provide the necessary reduction.

Protecting Feed and Water from Fallout

The principle of protecting stored feed and water from fresh fallout is simple: prevent the fallout from getting mixed into these materials. They may have been irradiated -- but if the fallout did not come into actual contact with them, or if the fallout were removed -- they would not be radioactive. They would be safe to eat, or drink.

Since early radioactive fallout is dustlike in character, initially it provides a surface contamination of those things upon which it falls. We can keep it out of feed and water in much the same way that we would keep out ordinary dust -- by placing a cover over them. And the fallout could be removed from some food products just as we get rid of dirt or dust -- by mechanical removal, such as washing, paring, vacuum cleaning, and brushing.

Grain stored in a permanent bin and ensilage in a covered silo would be adequately protected against fallout. The contents could be used as soon as a farmer could safely get into the area to handle them.

Livestock creep feeders, self-feeders, and covered feeders could protect essential feeds from fallout. Bunker and trench silos of all types -- if adequately covered -- could also provide protection.

A haystack in an open field could be protected by a cover such as a tarpaulin. When it is safe for the farmer to leave his shelter, he can carefully remove the cover and remove the fallout.

Many materials, such as uncovered haystacks and piles of farm produce, could be safely used if the contaminated outer portions were removed.

Water stored outside -- in stock water troughs, for example -- should be covered with any material that will normally keep out dust. Larger farm ponds and lakes would, of course, be difficult, if not impossible, to protect.

As time passes following an attack, contamination of ponds and lakes would become less and less of a problem. The dilution of the radioactive fallout in the water and its adsorption by clay on the sides and bottom of the lake would be effective in reducing the hazard below that of the surrounding land.

Water from covered sources such as springs and wells would be essentially free of contamination, even where the fallout was heavy, and could be used with confidence for man and animals. A good protected water supply from a well or spring, distributed through troughs and automatic livestock water fountains, would provide an excellent continuing source of safe water for animals. This would be especially useful during the initial emergency when the livestock owner may be confined to a fallout shelter and would not be able to attend his livestock.

After the first critical 24 to 48 hours following an attack -- or when outdoor work periods could be safely scheduled -- livestock could be given short periods of exercise in areas or yards that did not contain excessively contaminated vegetation or water. When it was no longer practical to keep animals off contaminated pastures, supplemental feeding with uncontaminated feed should be provided as far as possible.

Iodine 131

Iodine 131 is present in relatively large quantitites in fresh fallout. In dealing with the problem of iodine 131 contamination in milk, the ideal approach is the use of preventive or protective measures at the farm or production level -- to try to keep it from entering the milk. A dairy farmer, therefore, should confine his milking animals to the barn before fallout appears in the area and provide uncontaminated forage and feed. Since radioactivity from iodine 131 largely disappears from materials after a 60-day period, the dairyman could use forage and feed that had been stored for at least 60 days after exposure to fallout. Freshly contaminated forage could be fed to non-milking stock. Concentrate

mixtures prepared on the farm should be made up of grains harvested before the fallout or stored for 60 days or longer if fallout is extremely heavy.

The problems associated with this requirement would vary by season, geographical location, dairy practices, and available facilities.

Iodine 131 contamination of milk would be minimal in the northern states from fall to early spring when dairy animals are not usually on pasture but are normally housed and barn-fed.

In those areas where dry lot feeding is practiced, there should be little contamination of milk. Also, in those sections where a large part of the dairy ration is imported from other parts of the country, the delay in feed movement would result in feed of extremely low contamination.

Increased storage facilities would be required on some farms.

If, despite all precautions, fluid milk supplies should become contaminated, a number of steps could be taken to avoid danger to consumers. Since iodine 131 decays rapidly, delayed marketing is a key to safe usage of contaminated milk and dairy products.

Fluid Milk with High Content of Iodine 131

Suppose the contamination of milk supplies with iodine 131 was localized. Milk from other areas could be brought in for immediate consumption, and the contaminated milk could be processed and stored for later use. This measure would require a large, efficient field organization with a monitoring capability to assess the iodine 131 content of milk at production level and the levels of contamination in local areas. If contamination was widespread, however, this procedure would be impractical. Consumption of fresh fluid milk would have to be deferred until radioactivity was reduced to safe levels.

Fluid Milk with Relatively Light Content of Iodine 131

If contamination was relatively light, storage for 8 days might be adequate. (Eight days of storage would reduce the radioactivity by 50 percent.) Today's pasteurized homogenized milk should maintain its quality for this period at usual refrigeration temperatures. It is preferable that this storage take place before delivery to the consumer. Normally, three to four days are required for milk to reach the consumer. Few plants today have facilities to store milk for eight days. To do so would generally exceed available plant tank capacity and refrigerator facilities. A few plants could hold milk for six days. In general, industry would have to prepare specifically for the application of this countermeasure.

Frozen Fluid Milk

For high rates of contamination, storage for 30 to 60 days might be necessary before iodine 131 was reduced to safe levels. Storage for 60 days would reduce the radioactivity to less than 1 percent. Freezing of packaged milk in paper cartons for storage prior to delivery would be one way of handling the problem. The frozen product would be thawed before delivery to the consumer and the consumer would have no responsibility for keeping track of storage time. Storing frozen milk for two to three weeks would provide a decrease in the iodine 131 by 70 to 85 percent. During the period when fresh milk supplies were not available, reconstituted dry milk or evaporated milk could be safely used.

At the present time there are few freezing facilities at fresh milk plants. It is estimated that unused freezer space in public warehouses is available to store about one billion quarts of milk. This indicates the feasibility of storing single-strength milk as a possible countermeasure for iodine 131. This space is quite well distributed by population density and at least three-fourths of the available space could be effectively utilized. The use of home freezers could also be considered.

Any of these marketing modifications would be difficult, nevertheless they could become necessary. There should be no destruction of milk contaminated with iodine 131. Since its half-life is short, the milk could be processed into products such as butter, cheese, powdered milk and canned milk, and stored long enough to allow decay to take place.

Processed Milk

The use of powdered whole milk, powdered skim milk, and canned evaporated milk would provide safe products.

About 3 to 4 percent of our total fluid milk production is processed into evaporated milk. Of this, about 10 percent is consumed by infants up to 6 months of age, and the balance is utilized in home use. Industry maintains an even distribution across the country, and evaporated milk is sold in every state. The in-transit time to reach consumers is about 2 months. This would provide nearly 100 percent reduction in the intake of iodine 131.

It is estimated that of the infant group that is bottle fed on milk, about 60 percent are on evaporated milk. About 35 to 37 percent use commercial liquid or powdered products, which are about 20 percent powdered milk. About 2 to 5 percent are on fluid milk.

Powdered Milk

The production of powdered whole milk is extremely limited. Powdered skim milk production in the United States annually runs about two billion

pounds, of which over 200 million pounds are packaged for consumer use. The rest is used in baked goods, other dairy products, prepared mixes, meat products, candy, for government purchase, and other miscellaneous uses. Here again because powdered milk can be stored for a considerable time, the reduction of iodine 131 intake could be considered to be almost 100 percent.

Strontium 90

As the first few months passed following an attack, strontium 90 would take on new significance. Decay of the shorter-lived isotopes would leave strontium 90 as the principal material of radioactive contamination. In addition, the extremely small particles containing strontium 90 that had been carried into the stratosphere would be gradually reaching the earth.

In contrast to iodine 131, which has a half-life of 8 days, strontium 90 has a half-life of 28 years. It would be present in our environment for a long time.

Furthermore, strontium gains entrance into the food chain, where it behaves much like calcium in soils, plants, man, and animals. Some of the strontium in fallout collects on plants and is absorbed. Some washes into the soil and remains in the top several inches of uncultivated lands almost indefinitely. From here, it is taken up into the plants along with calcium.

A close relationship between rainfall and the mean strontium 90 content of milk has been demonstrated in both this country and England. Rainfall is the principal mechanism for delivery of strontium 90 to the ground from the upper levels of air.

When dairy animals eat contaminated plants, a small part of the radio-strontium -- only about 1 percent -- is secreted in milk. A very small part goes into muscles, and a part collects in the bones, where it remains for a number of years. So far, strontium does not seem to be a problem in relation to our water supply.

Strontium 89 is similar to strontium 90, except for a shorter half-life of 53 days.

Naturally, it's as important to protect a cow's feed supply from strontium as from iodine, but the problem must be attacked differently.

Some protection against strontium could be gained by adjusting crop production practices. For example, adding lime or gypsum to highly acid soils and fertilizer or organic matter to infertile soils could reduce strontium uptake by plants as much as 50 percent.

Altering Dairy Cattle Rations

Research studies clearly show that the level of strontium 90 contamination of milk will depend upon the amount of calcium and strontium in the ration.

In an environment contaminated with strontium 90, rations for dairy cattle can influence the strontium 90 content of milk. For maximum effect, one should, in principle, reduce the plant calcium to a minimum and increase the mineral calcium to a maximum. For example, a diet of grass hay, corn, and inorganic calcium would provide less strontium for the animal than a diet of legumes, clover, lespedeza, or alfalfa, which are good sources of calcium but which would contribute a greater amount of strontium.

There would seem, however, to be little to gain in simply adding mineral calcium to an otherwise adequate diet. First, any dietary modifications would have to be carried out continuously over a reasonably long period of time to permit adaptation of the animal. Secondly, it would be difficult to get a dairy cow to eat more than 200 to 300 grams of calcium per day, and higher levels might be inadvisable from the standpoint of the health of the animal.

By adding 2 or 3 percent $CaCO_3$ or other suitable calcium compounds to concentrate mixtures fed to dairy animals, the average calcium intake would be just about double. As an alternative practice an equivalent amount might be added by the farmer at the manger. This amount of extra calcium should not cause adverse long-time effects provided enough phosphorus is available in the ration.

Limited field studies indicate that there is a relationship between the economic status of the farm and the amount of worldwide fallout in the milk produced thereon. For example: dairy animals maintained on farms with fertile lands, good pastures, under good animal husbandry and farming practices, will produce milk with less radioactive iodine and strontium 90 than the animals reared on farms of a low economic level with poor land and undesirable farming practices.

These studies also show that improving the dairy animal's ration to increase its milk production will also tend to reduce the radioactive iodine content of the milk.

Soil Decontamination

There are further countermeasures that could be used against strontium 90 if it was present in the soil in amounts that constituted a serious hazard to the health of man. But these countermeasures are drastic -- for example, deep plowing to place the strontium below the root zone, removal of ground cover such as mulch or sod, or scraping fields to remove the top several inches of contaminated soil.

Discrimination

Fortunately, the metabolic processes of both man and animals act to reduce substantially the amount of strontium deposited in the bones of man, compared with the amount originally present in the vegetation and in the soil where it grows.

This protection mechanism is measured by the term "discrimination factor" and refers to the natural preference that a biological system has for calcium over strontium. Relatively more calcium than strontium is carried along as these minerals move together through the food chain from the soil to the plant then through the body to their resting place in the bones.

Strontium 90 and calcium are very similar in behavior, but strontium 90 moves more slowly in metabolic processes and across membranes in man and animals. The magnitude of discrimination may be small in a single metabolic process but by a succession of such processes, each one magnifying the preceding one, substantial discrimination does result.

In milk, the discrimination factor operates twice. The biological system of the cow screens out over 90 percent of the strontium from entering the milk, and the biological system of man screens out still more of the strontium from entering the bones.

Although 70 to 80 percent of the calcium in the average diet in this country comes from milk and cheese, calcium from these sources carries less than 50 percent of the strontium 90 associated with our foods. Plant foods -- grains, vegetables, fruits, etc. -- furnish about 15 percent of the calcium but because they are consumed directly, they furnish over 50 percent of the total soil-derived strontium 90.

The Food Protection Committee of the Food and Nutrition Board, National Academy of Sciences, has recently reported that "Milk has been the single food item most often used for analysis as an indicator of environmental radiocontamination. This is because milk is produced regularly year-round; is convenient to handle, bulk or aliquot; can be obtained so as to represent small or large areas; and does contain the most important radiocontaminants. It must be emphasized, however, that the most important parameter is the level of contamination of the total diet. The use of milk as an indicator food does not imply that a decrease in the consumption of milk would result in a decrease of the total strontium 90 intake. Foods substituted for milk would probably result in higher intake of strontium 90 because of the higher strontium 90/calcium ratio in such foods."

This point is dramatically emphasized in a study by Kulp and Schulert (Science, May 18, 1962) showing that in 1960 human bones from persons in cities in South America contained levels of strontium 90 about one-half as great as those analyzed from cities in the Northern Hemisphere, yet the fallout in the Southern Hemisphere is only about one-fourth that in

the Northern Hemisphere. This is attributed to the difference in diet, with a higher milk component in the Northern Hemisphere.

Research on animals indicates that a body well nourished with respect to calcium does not retain as much strontium as the body that is deficient in calcium.

Strontium 90 Removal from Milk

A pilot plant research project for removing radioactivity in milk is being conducted cooperatively by the Atomic Energy Commission, the Public Health Service, and the U. S. Department of Agriculture. This study was initiated in the fall of 1959. It was justified by the work of Dr. Migicovsky, Canada Department of Agriculture, and scientists of England and the University of Tennessee, Oak Ridge, where radioactivity was removed from milk on a laboratory scale. The present work is being conducted in the Dairy Products Laboratory at the Agricultural Research Center in Beltsville, Maryland, and at the Public Health Engineering Center in Cincinnati, Ohio.

We are justifiably pleased with the accomplishments of this work to date. It was only a couple of years ago that some of the country's leading dairy research scientists were extremely pessimistic about the practicality of removing strontium 90 from milk without major changes in the milk composition.

In the newly developed process, milk is passed over an ion exchange resin. This procedure is much like that accomplished in the water softener found in many homes today. A similar process has been used in the past in the production of low-sodium milk.

It was found that the removal of strontium from milk could be increased from 60 to over 90 percent by first acidifying the milk from the normal pH of 6.6 to 5.4. After its flow through the ion-exchange resin, the milk is then neutralized back to its original pH of 6.6. This is followed by high-temperature, short-time pasteurization, and flash condensation in a vacuum pan to remove the excess water added during the acidification and neutralization. Then the milk is homogenized. Tests show no appreciable change in the chemical composition or in the taste of milk processed by this technique.

The pilot plant studies at Beltsville include a fixed bed resin column installation and a moving bed resin contactor.

The fixed bed resin column installation was designed to process approximately 100 gallons of milk an hour. The columns must be regenerated when their capacity to remove radiostrontium falls off. Therefore, any fixed bed installation must necessarily contain a number of columns so that as one column is removing radiostrontium another is being charged or regenerated.

The moving-bed resin contactor handles the problems of resin regeneration, cleaning, sterilizing, and strontium removal in a continuous manner.

The process has been designed so that there is a minimum change in the major components of milk. This gives reasonable assurance that the ion balance in milk will not be affected to any appreciable degree. The process does increase the citrate, potassium, and sodium ions, and removes the stable strontium ions.

More laboratory research is required on several important aspects of the process. While this work is being undertaken, scientists also plan to study the commercial application of this promising procedure.

A study is now in progress to determine the nutritional qualities of the processed milk and the effects of possible changes in composition.

The microbiological problems that might be associated with the resin treatment process are also being investigated.

Determinations must be made on finding out what possible additives the resin could convey to the milk.

Rulings must also be made on necessary changes, if any, in milk regulations, if the dairy product composition is changed by the radionuclide removal process.

Intensive research will continue for modifications and improvements in the removal process that would reduce its cost or simplify its ease of operation.

SUMMARY

In a large measure, responsibility for protecting the Nation's food supply in a nuclear emergency rests on farmers themselves. Since no one knows where bombs might be exploded or where winds might carry the fallout, it's up to farmers everywhere to be prepared to protect their livestock and other agricultural resources.

A farmer needs to know the requirements for safeguarding animals and for producing safe animal food products. Then he can review his buildings and farming practices and be better prepared for protection if an attack comes.

It was pointed out that there are already available on most farms a number of facilities that could help protect livestock and feed. Except in highly contaminated areas, if these facilities were used to advantage following a nuclear attack, farmers would experience much less loss and would be in a better position to produce adequate supplies of healthful food. There are also procedures and practices that the producer and processor can take to provide safe dairy products following an emergency.

There are, of course, many questions that we still can't answer. Further studies are continuing and should provide increased understanding in this field.

Research is being carried out by the U. S. Department of Agriculture to develop more knowledge about protection from fallout, whether it is created by nuclear attack or extended bomb testing. In addition to the work on the removal of radioactivity from milk, there are four other major research areas, including:

1. The study of the movement of isotopes through the soil and into the plants, and the means by which this movement can be altered or minimized.

2. The study of the movement of radioactive isotopes from contaminated feed to milk, and the means of altering this movement.

3. The effects of both the external and internal emitters on the biological system of the dairy animal.

4. The decontamination of soil.

Other research in both public and private institutions is also aimed at developing methods of protecting against radioactive contamination in our foods. As we have seen, there are a number of methods that can be considered for use under emergency conditions. As the research continues, the fund of dependable knowledge in this field is growing.

Emphasis is made of the importance of making a determined effort to gain new knowledge and to see that good use is made of what we have. This will provide a protective shield that's vital to our dairy industry, to our food resources, and to our national defense.